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## (54) Film scanner

(57) A film scanner comprises a device for detecting scratches in cine film (1) and for masking them in the reproduced video signal. The detection of scratches is carried out only during the scanning of the areas between film frames, by means of infra-red light, using one of the optoelectrical converters normally used for generating the video signal, and is evaluated in a following defect-masking circuit.

A lamp (7) emits visible and infra-red light which passes through a filter (19), film (1) and is split into RGB components for detection by, for example, line sensors (13—15). Filter (19) may be a disc (Fig. 3 not shown) having an infra-red only transparent strip, and is rotated at such a speed that illumination via the strip coincides with scanning of the area between frames.

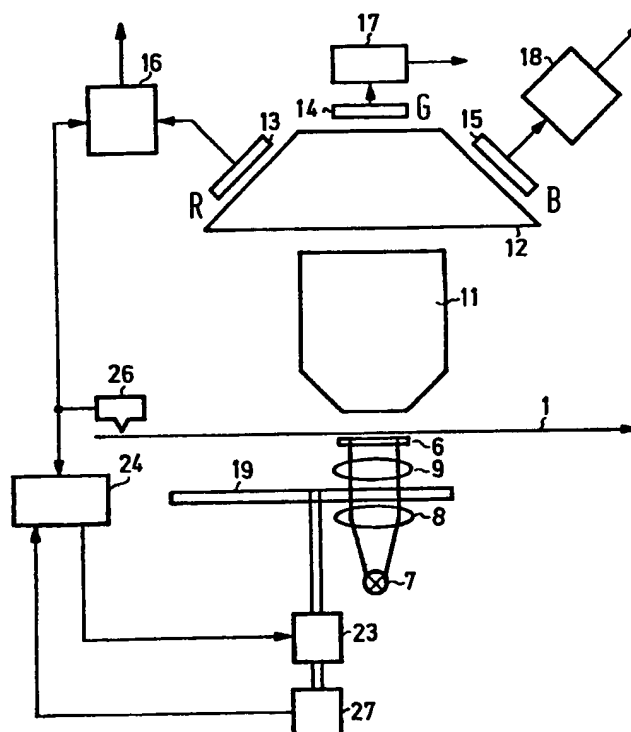


Fig. 2

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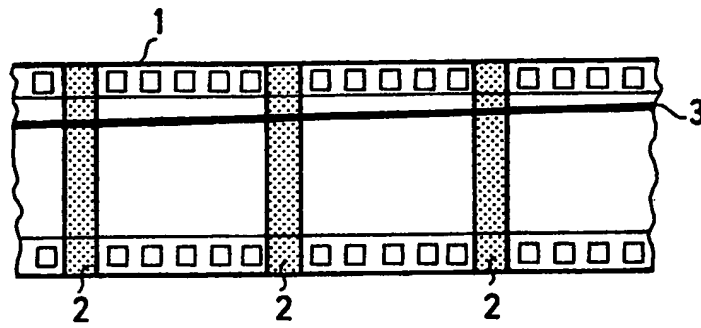


Fig. 1

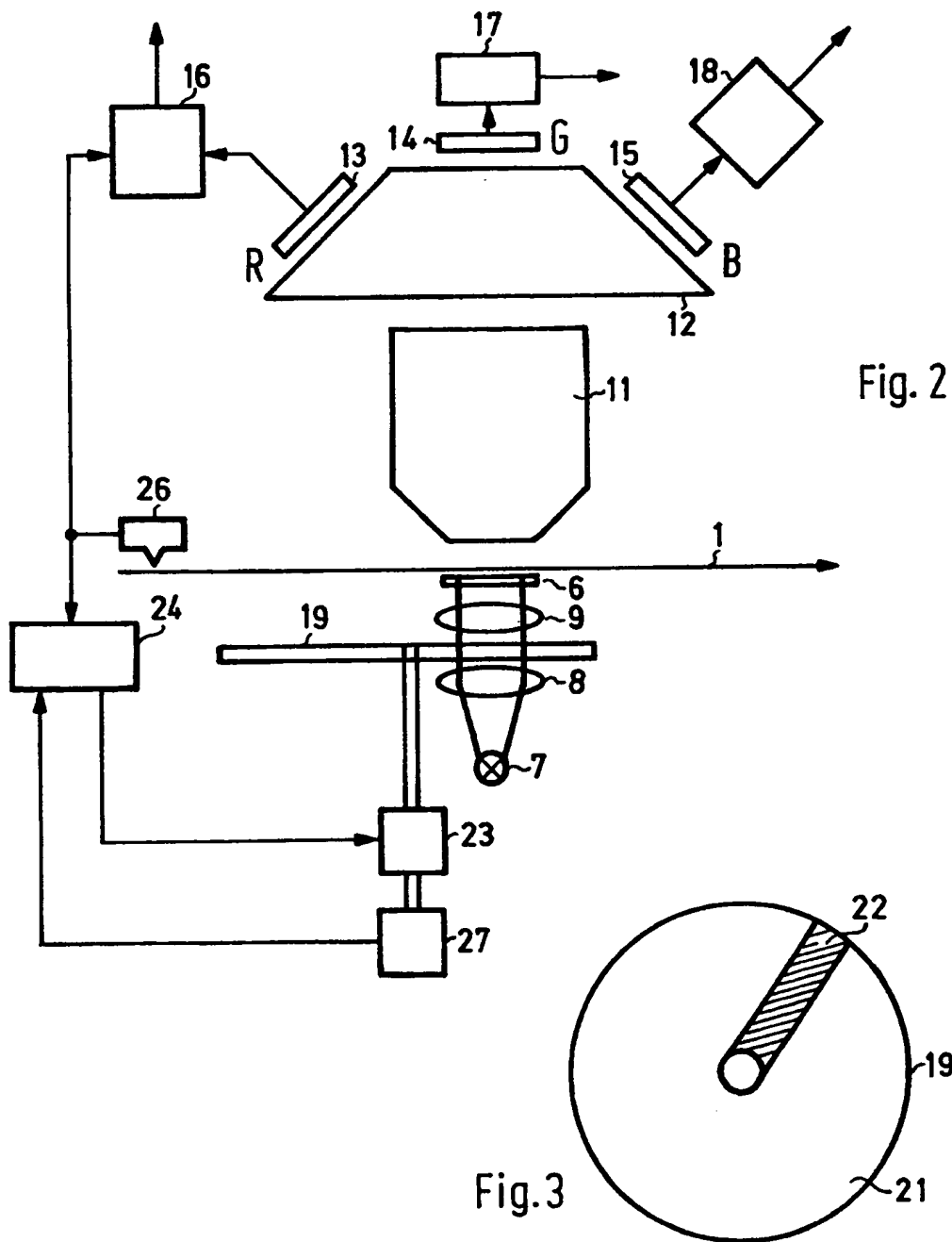
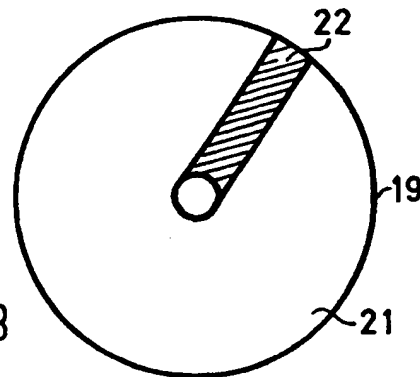


Fig. 2

Fig. 3



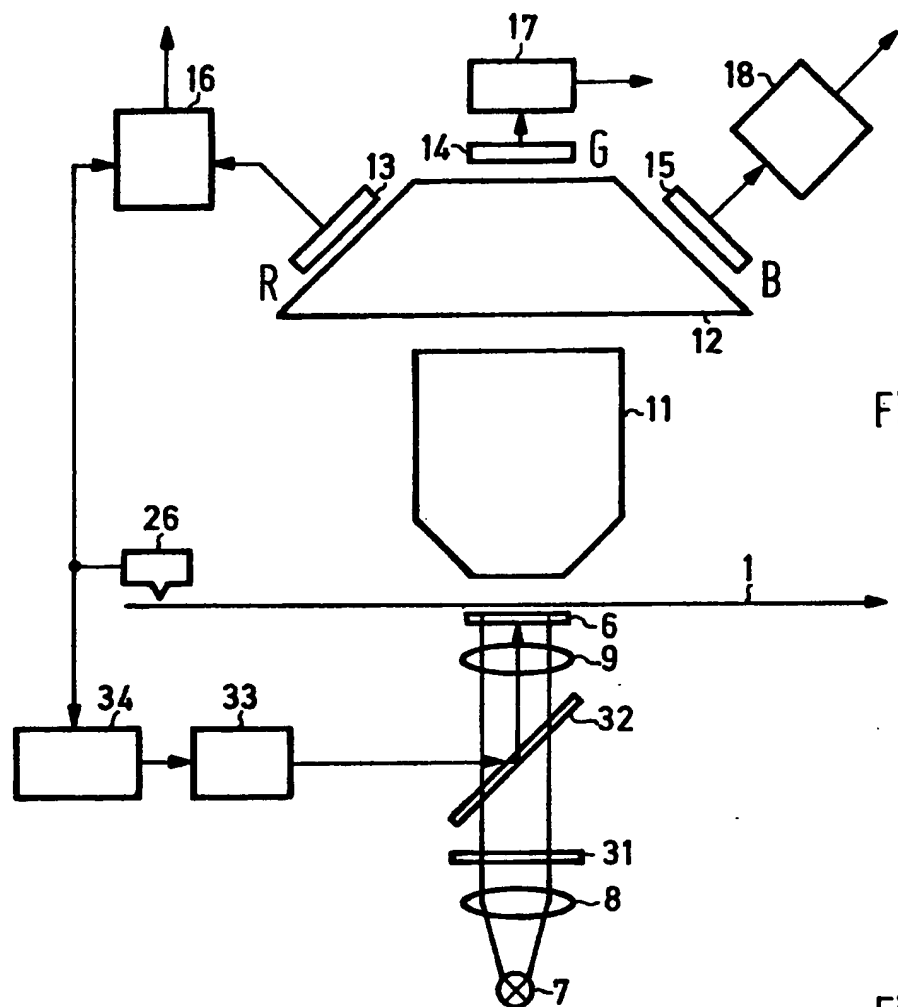


Fig. 4

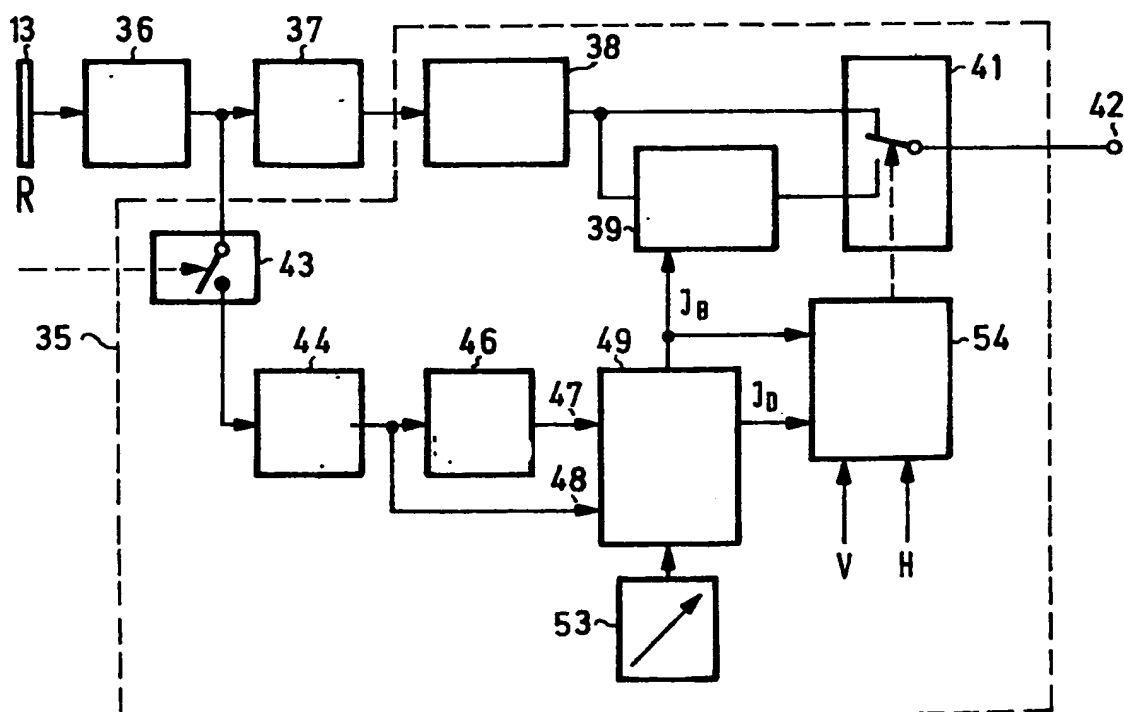


Fig. 5

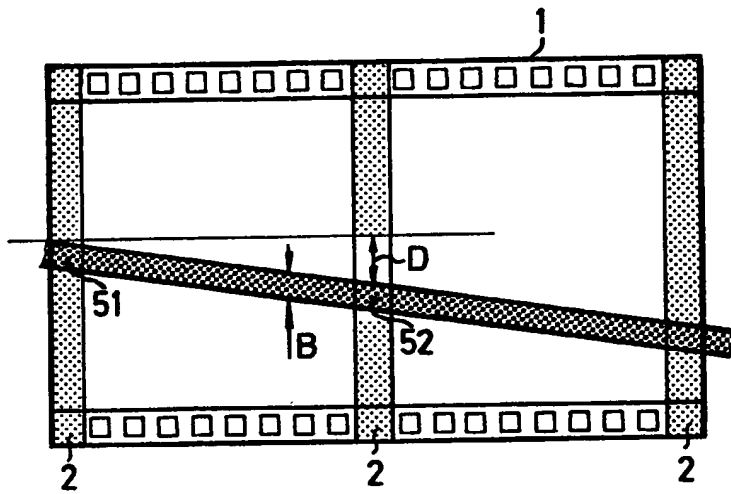


Fig. 6

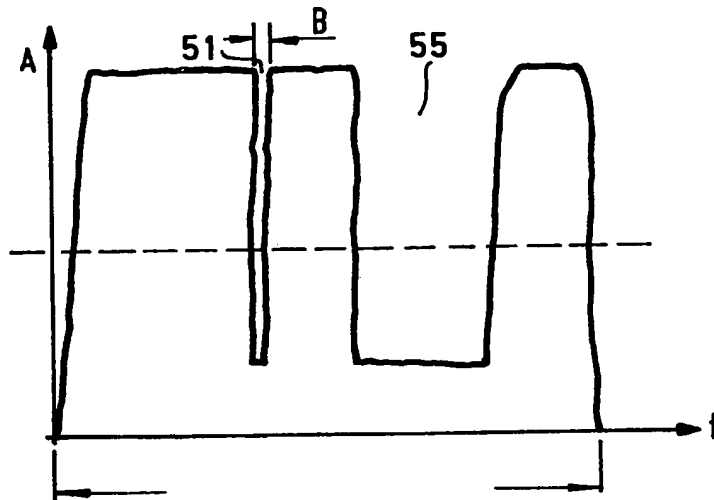


Fig. 7

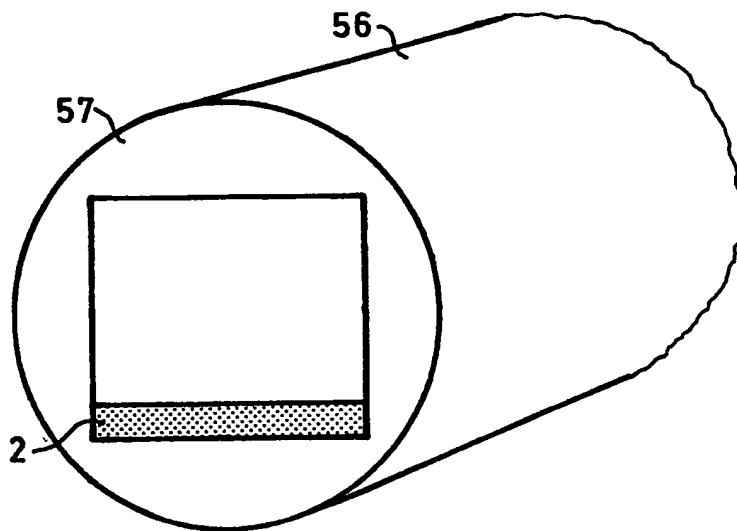


Fig. 8

# **SPECIFICATION** **Film scanner**

The invention is based on a film scanner according to the pre-characterising clause of the main claim.

Relatively old films which are frequently used often exhibit two types of defect in the picture region, namely, on the one hand, dirt and dust on the surface of the film and, on the other hand, scratches in the film-run direction, so-called running scars, which are caused by mechanical contact of the film guide elements with the picture region. In the electronic scanning and reversal of negative films these defects appear in a particularly disturbing way as white spots or scratches. Dirt and dust can for the most part be removed before scanning by means of a so-called film-cleaning machine. The disturbances caused by light refraction on scratches can be eliminated by scanning the film in a liquid of the same refractive index (so-called wet scanning). However, this wet scanning is expensive and complicated to operate.

G.B. Patent Specifications 1,547,811 and 1,547,812 already describe a purely electronic process for detecting and masking dirt and scratches. The process makes use of the fact that the dyestuffs of colour films allow infra-red light with wavelengths above 800 nm to pass through unimpeded. The video signal obtained from the infra-red light then contains only the information relating to dirt and scratches. As a function of this video signal, disturbed parts of the picture are replaced by adjacent undisturbed parts. To carry out this process, as well as the pick-ups for visible light (for example, for red, green and blue), an additional pick-up for infra-red light is required for colour-film scanning. At the same time, therefore, in addition to splitting the colour into the components red, green and blue, the infra-red image is blanked out. The infra-red sensor must have a specific adjustment relative to the other image sensors. A switching signal for controlling the masking is generated by means of horizontal and vertical signal delays. However, the possibilities for generating the substitute signal are not disclosed here.

The disadvantage of this known process is that a special, and therefore more expensive, colour separator, an additional high-resolution pick-up for infra-red, an additional preamplifier for obtaining the infra-red signal, and exact adjustment of the additional pick-up are necessary. Furthermore, it is extremely expensive to generate a further substitute video signal for extended areas of dirt of any shape because of the requisite horizontal and vertical interpolation circuits and the full-frame stores required, if appropriate, to obtain substitute signals from preceding film frames. Finally, if the areas of dirt are relatively large, the substitute signal may be unsuitable and consequently lead to visible picture interference.

The object on which the present invention is based is, therefore, whilst foregoing the expensive

masking of dirty parts which presents problems, to provide a process for masking the visibility of scratches in the film-run direction, so called running scars, without the additional blanking-out of an infra-red image and without using an additional sensor.

Practice has in fact revealed that most films are cleaned before being scanned and are therefore essentially free of dirt. As a result, it is necessary, in most cases, only to mask the visibility of scratches.

The advantage of the film scanner according to the invention, having the characterising features of the main claim, is that, in addition to avoiding the need for an additional infra-red light path, a substantially more simple defect-masking process is possible. Furthermore, the film scanner according to the invention offers the further advantage in comparison with wet scanning that even scratches extending into the dyestuff layer can be masked thereby.

Exemplary embodiments of the invention are illustrated in the drawing and explained in more detail in the following description.

In the drawing:

Figure 1 shows a portion of a scratched film, Figure 2 shows an exemplary embodiment of the film scanner according to the invention, Figure 3 shows a filter disc used in it, Figure 4 shows a further exemplary embodiment of the film scanner according to the invention, Figure 5 shows a block diagram of the masking circuit according to the invention, Figure 6 shows a further portion of a scratched film to explain the block diagram, Figure 7 shows a television-line video signal derived from the scratched film, Figure 8 shows a camera tube with an imaged film picture.

Figure 1 shows a portion of a motion-picture film 1 with three film frames. The film frames are separated from one another by information-free strips 2, so called frame lines. The frame lines 2 can be either transparent or covered with dyestuffs. Since the running scars 3 do not change or only slightly change their position from one film frame to the next, it is sufficient to carry out infra-red exposure of the film 1 just for the frame lines 2. The advantage of this is that the same pick-up can pick-up both the picture content in the film frame and the running scars 3 in the frame line 2. As a result, this also avoids the need for a special colour-separating prism.

The exemplary embodiment illustrated in Figure 2 contains only the parts of a film scanner which are necessary for explaining the invention. The film 1 to be scanned runs in the direction of the arrow through a film gate 6 in which it is illuminated via condenser lenses 8 and 9 by a projection lamp 7 which emits both visible and infra-red light. Located on the other side of the film 1 are imaging optics 11 which image the transilluminated film frame via a colour separator 12 on three opto-electrical converters 13, 14 and 15, for example

semi-conductor line sensors, for the three colour components red, green and blue. The converters 13, 14 and 15 are each connected to a video processing circuit 16, 17 and 18, at the outputs of which the red, green and blue colour signals can be picked up for further processing.

To detect scratches in the film 1, there is here a filter disc 19 which consists essentially of a part 21 opaque to infra-red light (see Figure 3) and a strip 22 transparent to infra-red light. The filter disc 19 is rotated by means of a motor 23. By means of a motor control circuit 24 which is regulated by a frame-line detector device 26 and by a position-indicating device 27, it is possible to adjust the rotational speed of the filter disc 19 in such a way that a frame line located in the film gate coincides with the strip 22. The frame-line detector device 26 can be, for example, a tachodisc coupled mechanically to a sprocket or it can be a perforation light barrier. As a result, the frame lines are each transilluminated additionally with infra-red light which is then evaluated in the video processing circuit 16 connected, for example, to the red converter 13 and containing a defect-masking circuit.

Another possibility of just transilluminating each of the frame lines with infra-red light is illustrated in Figure 4. In this Figure, the parts corresponding to those in Figure 2 each bear the same reference symbols. Here, a filter 31 opaque to infra-red light and intended for blocking the infra-red light generated by the lamp 7 and a mirror 32 reflecting infra-red light are provided between the projection lamp 7 and the film 1 within the condensor lenses 8 and 9. An infra-red light source 33 irradiates the mirror 32 in the form of pulses as a function of the position of the frame line in the film gate 6. For this purpose, the frame-line detector device 26 transmits an appropriate signal to a pulse control stage 34 which gates the infra-red light source 33 by means of pulses. During the scanning of the frame line, a row of light-emitting diodes can preferably be used as an infra-red light source when scanning is carried out in a continuous film run and with semiconductor line sensors.

Figure 5 illustrates the part of the video signal processing circuit 16 of the red sensor 13, which contains, for example, the defect-masking circuit 35. The video signal generated by the red sensor 13 is fed via a preamplifier 36 to a video processor 37, in which it is processed in a known way (for example, gamma correction, aperture correction, amplification etc). After that, it is entered in a full-frame store 38 which can store a film frame. The output of the store 38 is connected, on the one hand directly and, on the other hand, via a picture-element interpolator 39 to a picture-element change-over switch 41, at the output 42 of which the processed video signal can be picked up.

During the scanning of the frame line, a switch 43 controlled by the frame-line detector device 26 is closed, and the corresponding video signal of the frame line, which contains the scratch information, is transmitted to a switching-signal

shaper stage 44. This generates a pulse-shaped switching signal which, after being processed in the following stages, serves for changing over the video signal disturbed by scratches to an undisturbed, so-called masking signal.

Since the scratches can easily extend obliquely in the film frame (see, in this respect, Figure 6) and since a dirt spot could also be present coincidentally at the time of a video signal, to avoid faulty corrections the switching signal of two successive frame lines is formed by means of a delay device 46 for a film frame. Thus, the switching pulses derived from the scanned scratches 51 and 52 (Figure 6) are applied to the inputs 47 and 48 of a comparator stage 49. The width B of the scratches 51 and 52 is determined at the comparator stage 49 and the maximum defect width to be used for evaluation can be set by means of a setting circuit 53. As a result, wider particles of dirt, for example, are not taken into account at the same time. Furthermore, the comparator stage 49 also determines the difference D in the scratch positions of successive film frames (see Figure 6). A linear shape of the scratches is assumed here, this practically always being the case.

The width signal  $I_p$  emitted by the comparator stage 49 controls, on the one hand, the coefficients of the picture-element interpolator 39 for substituting an undisturbed video signal for the video signal disturbed by scratches and, on the other hand, a line counter 54 which, during the period of the disturbed video signal, switches the picture-element change-over switch 41 to the picture-element interpolator 39. The difference signal  $I_p$  likewise fed to the line counter 54 controls the position of the change-over signal along the television line, so that even oblique scratches are masked in the picture. Moreover, to synchronise the switching signal emitted by the line counter 54, the synchronising pulses for vertical and horizontal frequency, generated at the studio clock frequency, are also fed to this line counter. Thus, a video signal undisturbed by scratches can be picked up at the output 42. The image store 38 with a delay of one full-film frame ensures in the process that the video signal and switching signal are coordinated with one another correctly in time.

Figure 7 shows the video signal of a television line which is disturbed by a scratch 51 and by a dirt particle 55. As can easily be seen, the scratches produce substantially narrower disturbances of the video signal than the dirt particles, so that the scratches can easily be determined by means of a width discriminator circuit.

Figure 8 shows the front part of a camera tube 56 with an optoelectrical surface converter electrode 57, on which an entire film frame is imaged. To put the invention into practice even when these converters are used, a few lines of the frame line 2 are scanned in addition to the film frame, a film gate of a film projector, for example, ensuring that only the region of the frame line 2 is

illuminated with infra-red light. Here again, a masking signal can be derived from the video signal of the frame line.

#### CLAIMS

5 1. Film scanner with an illumination device transilluminating the film and emitting visible and infra-red light, with an optical device for imaging the film frames after separation into several colour components onto a number of optoelectrical converters corresponding to the colour components and with a device for detecting scratches in the film and for masking them in the reproduced video signal, characterised in that the detection of scratches (3) in the film (1) is carried out only during the scanning of the frame lines (2) located between the film frames by means of the infra-red light and by using at least one of the optoelectrical converters (13 or 14 or 15) and is evaluated in a following defect-masking circuit (35).

20 2. Film scanner according to Claim 1, characterised in that during the scanning of the frame lines (2) a filter (21) opaque to infra-red light is pivoted out of the beam path between the illumination device (7, 8, 9) and the film.

25 3. Film scanner according to Claim 2, characterised in that the filter (21) opaque to infrared light is pivoted out by means of a motor (23) controlled by a frame-line detector device (26) located in the vicinity of the film gate (6).

30 4. Film scanner according to Claim 2, characterised in that the filter (21) opaque to infra-red light is located in a filter disc (19) which also has a strip (22) transparent to infra-red light.

35 5. Film scanner according to Claim 4, characterised in that the length of the strip (22) transparent to infra-red light corresponds to the radius of the filter disc (19) and its width corresponds approximately to the frame-line width, and in that the filter disc (19) driven by the motor (23) rotates, and its rotational speed is regulated by the frame-line detector device (26) and an indicating device (27) for the motor position.

40 6. Film scanner according to Claim 1, characterised in that the illumination device (7, 8, 9) contains an additional infra-red light source (33) which is controlled by the frame-line detector device (26).

45 7. Film scanner according to Claim 6, characterised in that the additional infra-red light source (33) is activated by the frame-line detector

device (26) via a pulse control stage (34).

55 8. Film scanner with a continuous film run and with semiconductor line sensors as optoelectrical converters, according to Claim 7, characterised in that the additional infra-red light source (33) consists of a row of light-emitting diodes corresponding to the length of the line sensors.

60 9. Film scanner according to Claim 1, characterised in that, during the scanning of a frame line (2), when scratches (3) are present a switching signal is generated, by means of which the disturbed video signal is switched to a masking signal generated in a picture element interpolator (39).

65 10. Film scanner according to Claim 9, characterised in that, by means of the picture-element interpolator (39), the erroneous video-signal components produced as a result of scratches are substituted by preceding signal components stored in an image store (38).

70 11. Film scanner according to Claim 9, characterised in that the width (B) and position (D) of the scratches (3) and their angle relative to the running direction are determined by means of a comparison between the video signals of two successive frame lines (2).

75 12. Film scanner according to Claim 11, characterised in that the picture-element interpolator (39) is influenced as a function of the width (B) of the scratches which is determined.

80 13. Film scanner according to Claim 1, characterised in that the switching signal is influenced as a function of the width (B) and position (D) of the scratches (3).

85 14. Film scanner according to Claim 9, characterised in that a full-frame store (38) for delaying the video signal is provided in the video-signal path in front of the picture-element interpolator (39) for coordinating the video signal and switching signal with one another correctly in time.

90 15. Film scanner with optoelectrical surface converters (57), each for picking up one entire film frame, according to Claim 1, characterised in that, in addition to the film frame, at least one frame line part extending over a few lines of the television raster is imaged on the photosensitive layer of the converter (56) and only this part is illuminated with infra-red light.

95 16. A film scanner substantially as hereinbefore described with reference to the accompanying drawings.